

Shoal Creek Watershed Protection Plan (WPP) Development: Collaborative Review of Existing Data, Information and Reports

Authored and Prepared by:
Nick Dornak, Watershed Services Program Coordinator
The Meadows Center for Water and the Environment

Prepared in cooperation with the Texas Commission on Environmental Quality
and the U.S. Environmental Protection Agency

June 27, 2018



THE MEADOWS CENTER
FOR WATER AND THE ENVIRONMENT
TEXAS STATE UNIVERSITY

Introduction

City of Austin (COA) Watershed Protection Department data show that the Shoal Creek watershed is one of the most polluted, and most flood and erosion prone creek systems in Austin, Texas. The watershed has an area of 8,300 acres, a length of 16 miles, and includes more than 30 miles of streams. Shoal Creek flows north to south through central Austin. Once home to popular swimming and fishing destinations, the creek suffers from poor water quality, including elevated fecal bacteria and nutrient levels. Since 2002, elevated bacteria concentrations have been found in a tributary to Shoal Creek, the Spicewood Tributary (Segment 1403J), which is currently listed as impaired for bacteria on the *2014 Texas Integrated Report of Surface Water Quality*, as well as a concern for nitrate. In 2012, a Total Maximum Daily Load (TMDL) was developed to address bacteria and to evaluate attainment of the contact recreation use in Waller Creek, Walnut Creek, Spicewood Tributary on Shoal Creek and Taylor Slough South. TMDL compliance is based on maintaining “bacteria concentrations in the selected waters below the geometric mean criterion of *E. coli* less than 126 MPN/100 mL or fecal coliform less than 200 MPN/100 mL” (TCEQ 2015, Five Total Maximum Daily Loads for Indicator Bacteria in Four Austin Streams). Periodic water quality monitoring shows that bacteria in Shoal Creek often exceeds these levels and storm flows also have high levels of nutrients, sediments and other contaminants.

The highly urban character of the Shoal Creek watershed presents special challenges and requires a multifaceted approach to restoring water quality. Fifty-three percent of the watershed is surfaced in impervious cover. The bulk of development in the Shoal Creek watershed took place before the adoption of environmental protection regulations. Fifty-six percent of development in the watershed was built before the adoption of drainage regulations in 1974, and 71% was constructed before the adoption of water quality regulations in 1991. Currently, only 21% of the watershed’s impervious cover area is treated for water quality. Because of this, the watershed suffers from uncontrolled, polluted stormwater runoff and is equipped with an undersized, deteriorating storm drain system. Moreover, the watershed is slated for increased density and further redevelopment in the years to come, as the COA overhauls its Land Development Code. Over 1,300 residences and 94 commercial properties are located directly along Shoal Creek and its tributaries and an estimated 70,000 – 100,000 people reside in the watershed. Nonpoint source pollution is a major challenge for the Shoal Creek watershed, and the severity of this issue will increase if not addressed with a management plan as the population of the watershed grows. Human and canine fecal matter, fertilizer, sediment from erosion and construction sites, oil, grease, and other types of urban runoff all contribute to Shoal Creek’s nonpoint source pollution issue.

This report will serve to assess available data that may be used to characterize the Shoal Creek watershed in an effort to develop a Watershed Protection Plan (WPP). The development of the Shoal Creek WPP will build on existing efforts to improve water quality on the part of the COA and nonprofit groups. The Shoal Creek Conservancy (SCC) currently serves as the lead entity in the WPP development process with primary partners including the COA, Texas State University - The Meadows Center for Water and the Environment (Meadows), and Doucet & Associates (Doucet). Project funding and guidance is provided by the United States Environmental Protection Agency (EPA) and Texas Commission on Environmental Quality (TCEQ).

Per the Shoal Creek WPP (TCEQ Contract No. 582-18-80181) Scope of Work, Task 3: Data Acquisition and Coordination, Subtask 3.1 Review of Existing Data, Information, and Reports states, *“The Performing Party, in collaboration with project partners, will work to compile, assess, and quality assure any existing, updated, or new data, information, and reports that may be used in characterizing the watershed, determining current and future levels and sources of pollution, and identifying management needs. The Performing Party and its partners will assess existing water quality data and current monitoring efforts to determine if available data allows for comprehensive determination of sources and quantities of pollution.”*

Acquired Data for Shoal Creek WPP Development

No data will be collected specifically for developing the Shoal Creek WPP or submitted for inclusion in surface water quality monitoring information system (SWQMIS). The Data Acquisition Quality Assurance Project Plan (QAPP) [revised January 29, 2018] developed to support the Shoal Creek WPP provides a list of non-direct data types and data sources to be evaluated for acquisition. Table 1 (below) corresponds to Table B9.1 of the Shoal Creek WPP QAPP and includes an additional column for evaluation of the data.

Table 1. Evaluation of Non-Direct Data Types and Data Sources Identified for Development of the Shoal Creek WPP

Data Type	Monitoring Project/Program	Collecting Entity	Dates of Collection	QA Information	Data Use(s) and Evaluation
Biological Assessments	COA Environmental Integrity Index (EII)	COA	Entire period of record for all project stations. 1 event per year every other year at station SHL1 (TCEQ ID 15965), SHL2 (TCEQ ID 17309), SHL3 (TCEQ ID 17310), SHL4 (TCEQ ID 17311)	COA EII QAPP	Spatial and temporal trends Biological Assessment data for Shoal Creek watershed currently available for the following years – 2000, 2003, 2006, 2009, 2011, 2013, 2015 and 2017. EII data and summary data available for download through 2013 sampling event. Additional data and reports will be requested from the COA. Annual biological samples and physical stream assessments are conducted in the late Spring /early Summer. Benthic macroinvertebrates and diatoms are collected primarily from riffles during baseflow, but may be collected from intermittent pools if flow was absent. The annual assessment includes: <ul style="list-style-type: none"> • Benthic macroinvertebrate and diatom surveys • Stream and reach stability assessment • Non-contact recreational assessment • Habitat assessment • Flow measurement, canopy density, and bank full measurement • Photographs • Sediment sample (collected from watershed mouth sites only and submitted to DHL Analytical)
Census Data	TNRIS	TNRIS	Most recent available for all project stations	Individual organization QA procedures	GIS mapping/analysis Census Block, Block Groups and Tracts for the census 2010. Data has been joined and exported with all related Census tables
Census Statistical Areas	CAPCOG	CAPCOG	Most recent available for all project stations	Individual organization QA procedures	GIS mapping/analysis <i>Census and Demographic Data</i> – As a designated census information center through an agreement with the U.S. Census Bureau, CAPCOG provides data and analysis for a local and regional planners. <i>Central Texas Regional Data</i> – Compiled and updated annually this is a statistical and brief analytical overview of CAPCOG's 10-county region — Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Llano, Travis, and Williamson counties. The Central Texas

Data Type	Monitoring Project/Program	Collecting Entity	Dates of Collection	QA Information	Data Use(s) and Evaluation
					Regional Data page uses several interactive charts and graphs to help explain some of the region's most vital statistical data to include measures such as population growth, unemployment, college attainment, cost of living, gross regional product and more.
Climatic Data	LCRA Hydrologic Data	LCRA	Entire period of record for rain gages near and within the watershed	Individual organization QA procedures	Characterization of historical and recent climatic conditions associated with routine and storm monitoring events <ul style="list-style-type: none"> Three sites on Shoal Creek available through LCRA hydromet COA rainfall data. Archival precipitation data available for download through NCEI.
	NCEI	NOAA			
Drinking Water Data	COA	COA	Annual	Individual organization QA procedure	Temporal water quality trends COA – Austin Water provides annual report for drinking water quality including point of regulation, summary data, EPA MCL and possible sources of regulated substances.
Flooding	CAPCOG COA	CAPCOG	Most recent available for all project stations	Individual organization QA procedures	GIS mapping/analysis Updated floodplain boundaries will assist with future land development recommendations for WPP
Geology	USGS/UT-BEG	USGS	Most recent available for all project stations	USGS TNIRIS	GIS mapping/analysis A GIS database of geologic units and structural features in Texas, with lithology, age, data structure, and format
Groundwater Levels	TWDB Statewide Program	TWDB	Entire period of record for all stations	TWBD QAPP	Analysis of recharge, Desired Future Conditions, Trend analysis of groundwater level fluctuations Well selection by map or aquifer. TWDB data available for multiple wells within and adjacent to the watershed include: <ul style="list-style-type: none"> State Well Number Owner Water Use Elevation (ft) Well Depth (ft) Water Level Observation Type

Data Type	Monitoring Project/Program	Collecting Entity	Dates of Collection	QA Information	Data Use(s) and Evaluation
					<ul style="list-style-type: none">• Water Quality Available• Aquifer Code• Latitude (DD)• Longitude (DD)• County• Well Type The TWDB Groundwater Database (GWDB) provides additional information on well water levels observed and changes over the well’s full recorded history. Selection available by county, aquifer or individual well.
Groundwater Quality	Various Studies	BSEACD, USGS, TWDB, TWON, COA	various	Individual organization QA procedures	Spatial and temporal trends COA and TWDB databases provide groundwater quality data for sites within the Shoal Creek watershed. 27% of the Shoal Creek watershed (mostly in the norther portion of the watershed) overlays the Edwards Aquifer recharge zone. Understanding surface-groundwater interaction within the watershed will guide WPP development.
Hydrography	USGS NHD	USGS	Most recent available for all project stations	USGS	GIS mapping/analysis
Hydrologic Unit Code (HUC)	USGS NHD	USGS	Most recent available for all project stations	USGS	GIS mapping/analysis
Hydrology	USGS Flow Data	USGS	Available data for Entire period of record for stations 08156800 Shoal Ck. at W 12th St and 08156675 Shoal Ck. at Silverway Dr.	USGS database	Loading calculations, flow-adjustment of water quality data. Characterization of long-term flow conditions
Hydrology	TNRIS	TNRIS	Most recent available for all project stations	Individual organization QA procedures	GIS mapping/analysis
Land Cover	USGS National Land Cover Database 2011 (NLCD)	USGS	Most recent available for all project stations	USGS	GIS mapping/analysis Data available through COA including aerial photography 1940-2017, slope, contours, land use 2010, multiple pervious and impervious classified layers, zoning, watershed floodplain model, hydrography and other quality assured data. USGS, CAPCOG and TNRIS include additional land use and
Land Use	CAPCOG	CAPCOG	Most recent available for all project stations	Individual organization QA procedures	
	COA	COA			
	TNRIS	TNRIS			

Data Type	Monitoring Project/Program	Collecting Entity	Dates of Collection	QA Information	Data Use(s) and Evaluation
					land cover data for determining potential pollutant loading characteristics to assist in watershed characterization and guidance for WPP development.
Monitoring data	TCEQ SWQM	TCEQ	Entire period of record for all project stations	TCEQ CRP, SWQMIS database	Summary statistics and trend analysis
Petroleum Storage Tanks	TCEQ	TCEQ	Most recent available for all project stations	TCEQ QA Procedures	GIS mapping/analysis
Riparian corridor assessments	COA Watershed Erosion Assessments, COA Watershed Master Plans	COA	Completed Reports	Individual organization QA procedures	Spatial and temporal trends, water quality parameters
Roadways	TXDOT	TXDOT	Most recent available for all project stations	Individual organization QA procedures	GIS mapping/analysis
	CAPCOG	CAPCOG			
	COA	COA			
Soils	USDA NRCS	USDA	Most recent available for all project stations	USDA NRCS	GIS mapping/analysis Digital soil geographic databases include: <ul style="list-style-type: none"> • Land Resource Regions (LRR) and Major Land Resource Areas (MLRA) • Common Resource Areas (CRA) • U.S. General Soil Map (STATSGO2) • Soil Survey Geographic (SSURGO) Database • Gridded Soil Survey Geographic (gSSURGO) Database • National Cooperative Soil Survey Soil Characterization Database (Pedons) Soil properties necessary to characterize the watershed and to incorporate into the OSSFs' density analysis.
Surface water quality (ex. Station ID, stream segment, routine, storm event, bacteria, TSS, conductivity, pH, temperature, dissolved oxygen, nutrients, other relevant surface water quality data)	COA Environmental Integrity Index (EII)	COA	Entire period of record for all project stations. 4 events per year every other year at station SHL1 (TCEQ ID 15965), SHL2 (TCEQ ID 17309), SHL3 (TCEQ ID 17310), SHL4 (TCEQ ID 17311)	COA EII QAPP/LCRA QAPP	Spatial and temporal trends, water quality parameters COA EII data reports provide the most comprehensive data available for the Shoal Creek watershed with routine water quality and biologic data being collected since 2000. Data was collected adhering to the Water Resource Evaluation Standard Operating Procedures Manual (SR-04-04). The collection of quarterly water quality sample at any given site is carried out during baseflow conditions (non-stormflow). During all sampling events (both quarterly and annual) physico-chemical measurements are collected with a

Data Type	Monitoring Project/Program	Collecting Entity	Dates of Collection	QA Information	Data Use(s) and Evaluation
					<p>multiprobe (Hach Hydrolab or Quanta Datasonde). These in-situ field measurements include:</p> <ul style="list-style-type: none"> • Dissolved Oxygen (mg/L) • Specific Conductivity (µS/cm) • pH (Standard Units) • Water Temperature (°C) <p>Quarterly water samples are collected and submitted to the LCRA Environmental Laboratory and analyzed for:</p> <ul style="list-style-type: none"> • Ammonia as N (mg/L) • Nitrate as N (mg/L) • Total Kjeldahl N (mg/L) • Orthophosphorus as P (mg/L) • Total Suspended Solids (mg/L) • <i>Escherichia coli</i> bacteria (MPN/100ml) (for Barton, Bull, Onion and Walnut sites only) <p>Quarterly water samples that are analyzed at the COA laboratory were analyzed for:</p> <ul style="list-style-type: none"> • Turbidity (NTU) • <i>Escherichia coli</i> bacteria (MPN/100ml) (for sites that will not be submitted for CRP/TMDL program) <p>From the <u>EII (2013-14) Watershed Summary Report</u> – “<i>E.coli</i> concentrations have historically been elevated throughout Shoal Creek likely due to aging wastewater infrastructure. Many sewer lines within and adjacent to the creek have been removed, but several remain. This watershed has a large residential component that was built in the early 1900’s with low integrity wastewater lines such as Orangeburg pipe. As these lines get replaced and there are other incremental improvements to the wastewater infrastructure</p>

Data Type	Monitoring Project/Program	Collecting Entity	Dates of Collection	QA Information	Data Use(s) and Evaluation
					that services this watershed, the total bacteria load should decrease”
Surface water quality (ex. Station ID, stream segment, routine, storm event, bacteria, TSS, conductivity, pH, temperature, dissolved oxygen, nutrients, other relevant surface water quality data)	USGS water quality sampling cooperative agreement with COA	USGS/COA	4 events per year at station 08156800 Shoal Ck. at W 12th St	USGS <i>Draft</i> QAPP	Stormwater quality trends
Surface water quality (ex. Station ID, stream segment, routine, storm event, bacteria, TSS, conductivity, pH, temperature, dissolved oxygen, nutrients, other relevant surface water quality data)	CRP Data	LCRA, COA	Quarterly monitoring	LCRA QAPP	Temporal trends, state Clean Rivers Program
Surface water quality (ex. Station ID, stream segment, routine, storm event, bacteria, TSS, conductivity, pH, temperature, dissolved oxygen, nutrients, other relevant surface water quality data)	LCRA - Colorado River Watch Network (CRWN)	CRWN	Entire period of record for all project stations	CRWN QAPP	Spatial and temporal trends, water quality parameters
Wells	TWDB	TWDB	Entire period of record for all project stations	TWDB QA procedures	Well location, owner, driller, and data See groundwater levels (above) for additional information on the wells in the TWDB database.

October 31, 2019

Y2 Acquired Data Summary Report for Development of the Shoal Creek Watershed Protection Plan

Data Files and Sources acquired by Doucet for water quality modeling:

- GIS Watershed Existing and Future Land Use Conditions
 - Landuse data was used to calculate the pollutant load in SELECT
 - Source: City of Austin (COA)
- Hydrology
 - Daily data mean flows were obtained from the United States Geological Survey (USGS) stream for Shoal Creek flow gages at 12th Street. The data period obtained was from 01/09/1983 through 07/31/2018.
 - Source: COA
- LDC Input Parameters
 - Observed data for Total Phosphorus (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS) were obtained from the COA and USGS at sampling locations at or near 12th Street.
 - Source: COA
- Austin FEWS Rainfall Gauge Data
 - File name: COA_FEWS2400_RainfallwithStage.txt
 - Rainfall data collected by the COA from 10/2015-09/2018 was used to model water quality of the watershed in SELECT
 - Source: COA (Rich Robinson)
- Shoal Creek W 45th Street Rainfall Data
 - ShoalCreekatW45thStreet_rain.csv
 - Rainfall depth data for Shoal Creek at W 45th Street collected from 9/10/2018-10/30/2018.
 - Rainfall data collected by the COA from 10/2015-09/2018 was used to model water quality of the watershed in SELECT
 - Source: COA (Rich Robinson)
- USGS Shoal Creek Rainfall Monitoring Data
 - Filename: USGS_ShoalCreek08156675-6800_RainvieuxNEXRADRainfall_HourlyTotals(in).xlsx
 - More rainfall data received to help model Shoal creek LDC curves
 - Source: COA (Rich Robinson)

City of Austin Surface Water Quality and Spatial/Temporal Trends – Environmental Integrity Index (EII) Data

COA EII data reports provide the most comprehensive data available for the Shoal Creek watershed with routine water quality and biologic data being collected since 2000. Data was collected adhering to the Water Resource Evaluation Standard Operating Procedures Manual (SR-04-04). The collection of quarterly water quality sample at any given site is carried out during baseflow conditions (non-stormflow). During all sampling events (both quarterly and annual) physico-chemical measurements are collected with a multiprobe (Hach Hydrolab or Quanta Datasonde). These in-situ field measurements include:

- Dissolved Oxygen (mg/L)
- Specific Conductivity ($\mu\text{S}/\text{cm}$)
- pH (Standard Units)
- Water Temperature ($^{\circ}\text{C}$)

Quarterly water samples are collected and submitted to the LCRA Environmental Laboratory and analyzed for:

- Ammonia as N (mg/L)
- Nitrate as N (mg/L)
- Total Kjeldahl N (mg/L)
- Orthophosphorus as P (mg/L)
- Total Suspended Solids (mg/L)
- *Escherichia coli* bacteria (MPN/100ml) (for Barton, Bull, Onion and Walnut sites only)

Quarterly water samples that are analyzed at the COA laboratory were analyzed for:

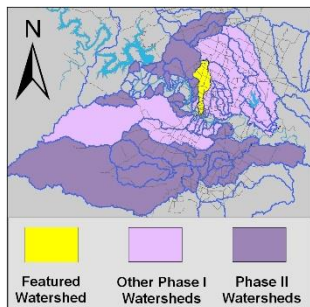
- Turbidity (NTU)
- *Escherichia coli* bacteria (MPN/100ml) (for sites that will not be submitted for CRP/TMDL program)

Data Summaries from Shoal Creek Watershed Characterization Report – Appendix A

Shoal Creek Watershed

Summary Sheet

Catchment	Total area		13 square miles				
	Area in recharge		3 square miles				
	Creek length		11 miles				
	Receiving water		Town Lake				
Demographics	2000 population		59,011				
	2030 projected population		78,759				
	30 year projected % increase		33 %				
Land Use	Impervious cover (2003 estimate)		47.3 %				
	Impervious cover (2013 estimate)		53.3 %				
Overall EII Scores	2000	2003	2006	2009	2011	2013	2015
	60	54	55	63	57	59	63



Map of the Shoal Creek Watershed showing the featured watershed (yellow) and other watersheds (purple). The map includes a north arrow and a legend indicating the color coding for the featured watershed, other Phase I watersheds, and Phase II watersheds.

Featured Watershed Other Phase I Watersheds Phase II Watersheds

Flow Regime* for Sample Sites on Shoal Creek Upstream to Downstream

Flow Regime for Sample Sites on Shoal Creek Upstream to Downstream																																				
Site	2001		2003							2006							2009					2010	2011					2013					2015			
	Feb	Feb	Feb	Mar	Mar	May	Sep	Dec	Feb	May	Jul	Aug	Nov	Feb	May	May	Oct	Dec	Dec	Mar	Jun	Jun	Sep	Jan	Apr	May	Jun	Jun	Sep	Jan	Apr	Jul	Sep			
	WQ	Bio	WQ	WQ	Bio	WQ	WQ	WQ	WQ	WQ	Bio	WQ	WQ	WQ	WQ	Bio	WQ	WQ	WQ	WQ	WQ	Bio	WQ	WQ	WQ	Bio	WQ	WQ	Bio	WQ	WQ	WQ	WQ			
118	B	B	B	B	B	B	B	n	B	B	B	n	B	B	B	B	B	B	n	B	n	n	n	B	B	B	B		B	B	B	B	n			
117	B	B	B	B	B	B	B	B	B	B	B	n	B	B	B	B	B	B	B	B	B	n	n	n	B	B	B	B		B	B	B	B	n		
116	B	B	B	B	B	B	B	B	B	B	B	n	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B		
122	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	B			

* B = baseflow

n = no flow

S = storm flow

blue = Samples were taken
visited

light blue = Samples were not taken

blank = not

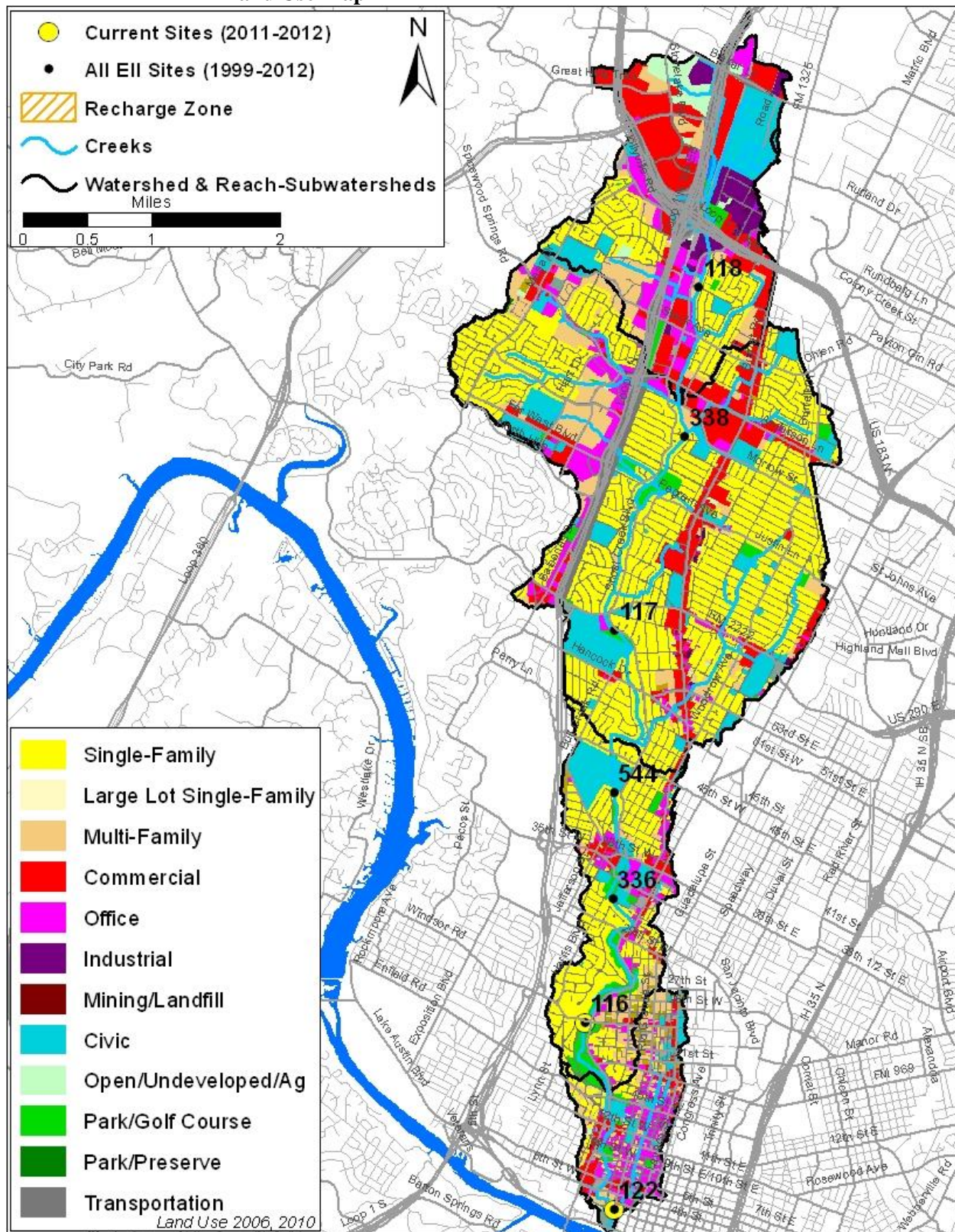
Index Scores* for Shoal Creek Sites by Year

Reach	Site	Site Name	Year	Water Quality	Sediment*	Contact Rec.	Non-Contact Rec.	Physical Integrity	Aquatic Life	Benthic subindex	Diatom subindex	Total EII Score
SHL1	122	Shoal Creek Upstream of 1st St.	1996	27	51	14	37	58	35	30	39	37
SHL2	116	Shoal Creek @ 24th Street	1996	41	51	45	68	51	52	52	51	51
SHL3	117	Shoal Creek @ Shoal Edge Court (EII)	1996	56	51	93	79	60	54	69	38	66
SHL4	118	Shoal Creek DS of Crosscreek Drive	1996	63	51	24	59	50	51	32	70	50
SHL1	122	Shoal Creek Upstream of 1st St.	2000	44	89	63	64	33	37	31	42	55
SHL2	116	Shoal Creek @ 24th Street	2000	53	89	74	63	26	38	40	36	57
SHL3	117	Shoal Creek @ Shoal Edge Court (EII)	2000	62	89	65	77	45	39	40	37	63
SHL4	118	Shoal Creek DS of Crosscreek Drive	2000	64	89	75	63	42	62	60	64	66
SHL1	122	Shoal Creek Upstream of 1st St.	2003	32	68	60	34	35	45	34	56	46
SHL2	116	Shoal Creek @ 24th Street	2003	51	68	41	66	32	36	29	43	49
SHL3	117	Shoal Creek @ Shoal Edge Court (EII)	2003	62	68	62	65	65	36	32	40	60
SHL4	118	Shoal Creek DS of Crosscreek Drive	2003	68	68	67	68	54	37	41	32	60
SHL1	122	Shoal Creek Upstream of 1st St.	2006	34	59	30	59	46	38	30	45	44
SHL2	116	Shoal Creek @ 24th Street	2006	48	59	24	79	47	64	62	66	54
SHL3	117	Shoal Creek @ Shoal Edge Court (EII)	2006	67	59	49	72	57	59	58	60	61
SHL4	118	Shoal Creek DS of Crosscreek Drive	2006	70	59	59	53	58	56	53	59	59
SHL1	122	Shoal Creek Upstream of 1st St.	2009	48	60	25	79	57	79	83	75	58
SHL2	116	Shoal Creek @ 24th Street	2009	64	60	28	84	59	94	91	97	65
SHL3	117	Shoal Creek @ Shoal Edge Court (EII)	2009	69	60	37	78	72	79	90	68	66
SHL4	118	Shoal Creek DS of Crosscreek Drive	2009	76	60	36	83	49	74	65	82	63
SHL1	122	Shoal Creek Upstream of 1st St.	2011	36	70	25	55	54	53	46	60	49
SHL2	116	Shoal Creek @ 24th Street	2011	62	70	48	80	50	62	61	63	62
SHL3	117	Shoal Creek @ Shoal Edge Court (EII)	2011	79	70	62	76	63	64	60	67	69
SHL4	118	Shoal Creek DS of Crosscreek Drive	2011	85	70	25	42	60				47
SHL1	122	Shoal Creek Upstream of 1st St.	2013	36	62	25	56	41	82	80	84	50
SHL2	116	Shoal Creek @ 24th Street	2013	60	62	31	83	47	81	80	82	61
SHL3	117	Shoal Creek @ Shoal Edge Court (EII)	2013	74	62	48	63	58	83	84	81	65
SHL4	118	Shoal Creek DS of Crosscreek Drive	2013	71	62	28	83	56	62	66	57	60
SHL1	122	Shoal Creek Upstream of 1st St.	2015	37	60	25	77	60	79	83	75	56
SHL2	116	Shoal Creek @ 24th Street	2015	57	60	65	72	51	79	87	71	64
SHL3	117	Shoal Creek @ Shoal Edge Court (EII)	2015	60	60	40	81	70	84	90	78	66
SHL4	118	Shoal Creek DS of Crosscreek Drive	2015	70	60	38	81	65	79	78	79	66

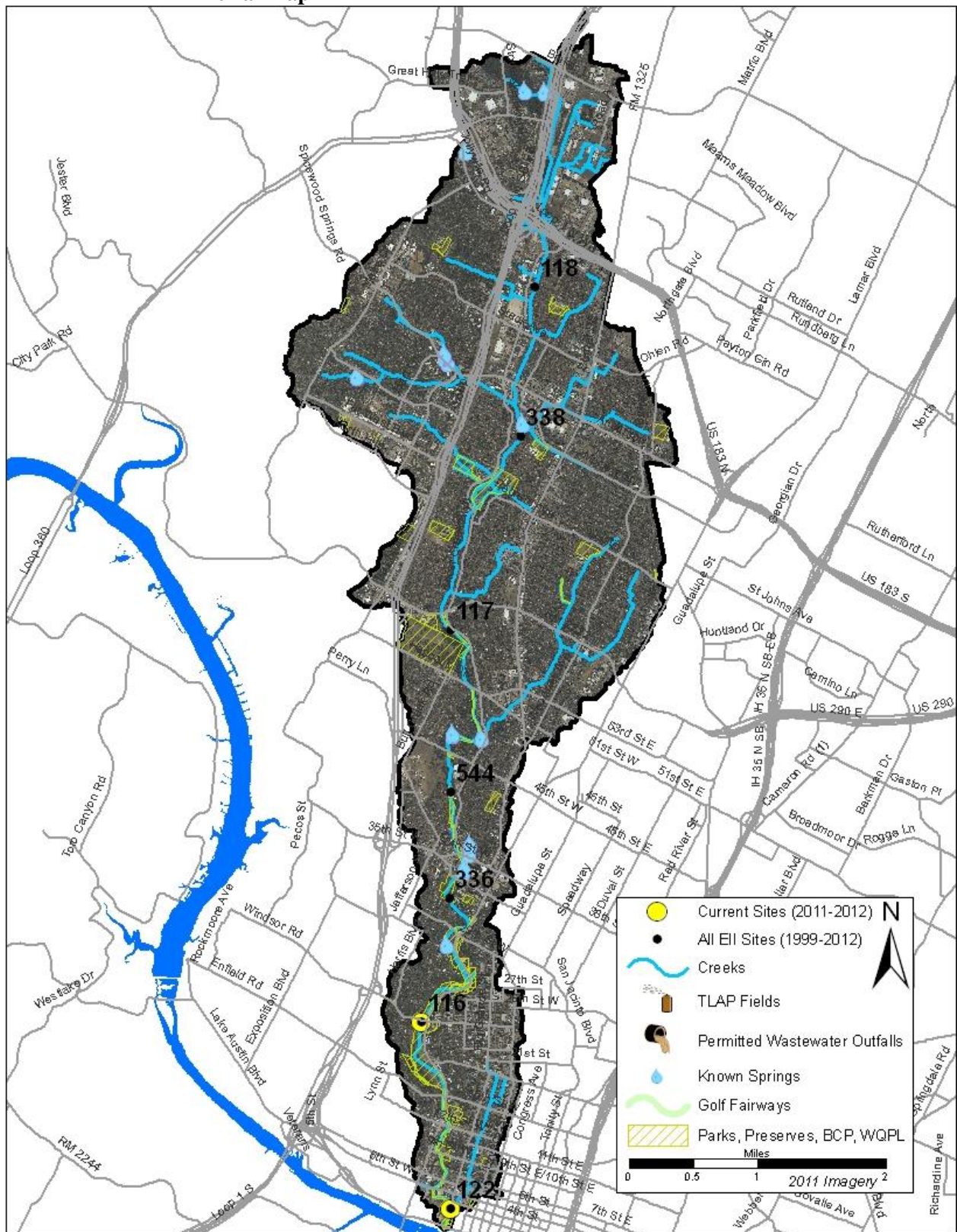
* blank cells indicate parameter was not collected, blank columns indicate site was dropped **sediment samples only collected at the downstream site

100-87.5 Excellent
 87.5-75 V. Good
 75-62.5 Good
 62.5-50 Fair
 50-37.5 Marginal
 37.5-25 Poor
 25-12.5 Bad
 12.5-0 V. Bad

Land Use Map



Aerial Map



Shoal Creek Watershed

Water Quality Data – Temperature, Conductivity, pH, Dissolved Oxygen & *E. coli* for 2015 Sample Sites (Downstream to Upstream)

Qualifiers to the left of the value	>	Greater than	Qualifiers to the right of the value	(blank)	Useable
	<	Less than		S	Exceeds standard range
	<J	Less than detected limit		R	Rejected, failed QC
	J	Estimated			

Watershed	Site	EII Reach	Date	Temp.	Cond.	pH	D.O.	E. Coli
Shoal	122	SHL1	01/14/2015	9.9	687	7.93	10.6	> 2419.6
Shoal	122	SHL1	04/15/2015	20.5	842	7.86	7.2	> 2419.6
Shoal	122	SHL1	07/10/2015	25.9	839	7.84	5.6	
Shoal	122	SHL1	07/14/2015	26.9	873	7.98	6.7 R	1203.3
Shoal	122	SHL1	09/09/2015	26.8	812	7.70	4.8	727.0
SHL1 Mean				22.0	810	7.86	7.0	1692.4
Shoal	116	SHL2	01/14/2015	8.3	741	7.97	12.3	365.4
Shoal	116	SHL2	04/15/2015	24.9	952	8.31	18.0	32.8
Shoal	116	SHL2	07/10/2015	28.0	934	8.09	10.8	
Shoal	116	SHL2	07/14/2015	31.3	921	8.15	10.6 R	63.6
Shoal	116	SHL2	09/09/2015	28.7	921	7.89	9.0	14.5
SHL2 Mean				24.2	894	8.08	12.1	119.1
Shoal	117	SHL3	01/14/2015	6.6	387	7.88	10.4 R	86.7
Shoal	117	SHL3	04/15/2015	17.9	759	7.62	5.8	153.9
Shoal	117	SHL3	07/10/2015	28.1	593	8.09	10.4	
Shoal	117	SHL3	07/14/2015	26.0	666	7.86	6.9	648.8
SHL3 Mean				19.7	601	7.86	8.4	296.5
Shoal	118	SHL4	01/14/2015	6.5	421	7.89	11.4 R	344.8
Shoal	118	SHL4	04/15/2015	17.7	561	7.52	5.3	107.1
Shoal	118	SHL4	07/10/2015	27.2	523	7.97	10.8	
Shoal	118	SHL4	07/14/2015	25.0	593	9.14	4.8	387.0
SHL4 Mean				19.1	524	8.13	8.1	279.6
Shoal Mean				21.5	724	7.98	9.0	641.0

Gray highlighting indicates that the value exceeds one standard deviation from the mean of all E.I.I. sites combined.

Summary Statistics for all 2015-2016 E.I.I. Sites Combined					
Parameter	2015-2016 Average	2015-2016 Minimum	2015-2016 Maximum	1 Standard Deviation Above	1 Standard Deviation Below
Temperature (C°)	20.7	5.8	34.2	27.5	
Conductivity (uS/cm)	722	160	3549	955	
pH (Standard units)	7.86	5.85	10.25	8.24	7.47
D.O. (mg/l)	7.9	0.1	18.7	10.4	5.5
<i>E. Coli</i> (col/100ml)	316.1	1.0	2420.0	883.7	

Shoal Creek Watershed

Water Quality Data – Ammonia, Nitrate / Nitrite, Ortho-Phosphorus, Total Suspended Solids & Turbidity for 2015 Sample Sites (Downstream to Upstream)

Qualifiers to the left of the value	>	Greater than	Qualifiers to the right of the value	(blank)	Useable
	<	Less than		S	Exceeds standard range
	<J	Less than detected limit		R	Rejected, failed QC
	J	Estimated			

Watershed	Site	EII Reach	Date	NH3-N	NO3/NO2	Ortho-P	T.S.S	Turb.
				<> flag	<> flag	<> flag	<> flag	<> flag
Shoal	122	SHL1	01/14/2015	<J 0.008	1.40	0.023	1.3	4.2 R
Shoal	122	SHL1	04/15/2015	0.081	1.59	0.064	6.8	2.0
Shoal	122	SHL1	07/10/2015					
Shoal	122	SHL1	07/14/2015	0.029	2.42	0.041	1.3	3.4 R
Shoal	122	SHL1	09/09/2015	0.039	2.50	0.130	<J 1.0	1.9 R
SHL1 Mean				0.039	1.98	0.064	2.6	2.8
Shoal	116	SHL2	01/14/2015	<J 0.008	1.00	<J 0.004	3.5	12.1 R
Shoal	116	SHL2	04/15/2015	<J 0.008	0.11	<J 0.004	1.4	4.4
Shoal	116	SHL2	07/10/2015					
Shoal	116	SHL2	07/14/2015	0.032	0.54	<J 0.004	10.2	2.2 R
Shoal	116	SHL2	09/09/2015	<J 0.008	0.04	<J 0.004	2.5	1.7 R
SHL2 Mean				0.014	0.42	0.004	4.4	5.1
Shoal	117	SHL3	01/14/2015	<J 0.008	0.53	<J 0.004	3.0	5.3 R
Shoal	117	SHL3	04/15/2015	<J 0.008	0.29	<J 0.004	<J 1.1	1.6
Shoal	117	SHL3	07/10/2015					
Shoal	117	SHL3	07/14/2015	<J 0.008	0.95	<J 0.004	<J 1.0	2.7 R
SHL3 Mean				0.008	0.59	0.004	1.7	3.2
Shoal	118	SHL4	01/14/2015	<J 0.008	0.35	<J 0.004	4.2	2.7 R
Shoal	118	SHL4	04/15/2015	<J 0.008	0.09	<J 0.004	<J 1.1	0.9
Shoal	118	SHL4	07/10/2015					
Shoal	118	SHL4	07/14/2015	<J 0.008	0.03	<J 0.004	<J 1.0	1.1 R
SHL4 Mean				0.008	0.16	0.004	2.1	1.6
Shoal Mean				0.018	0.84	0.021	2.8	3.3

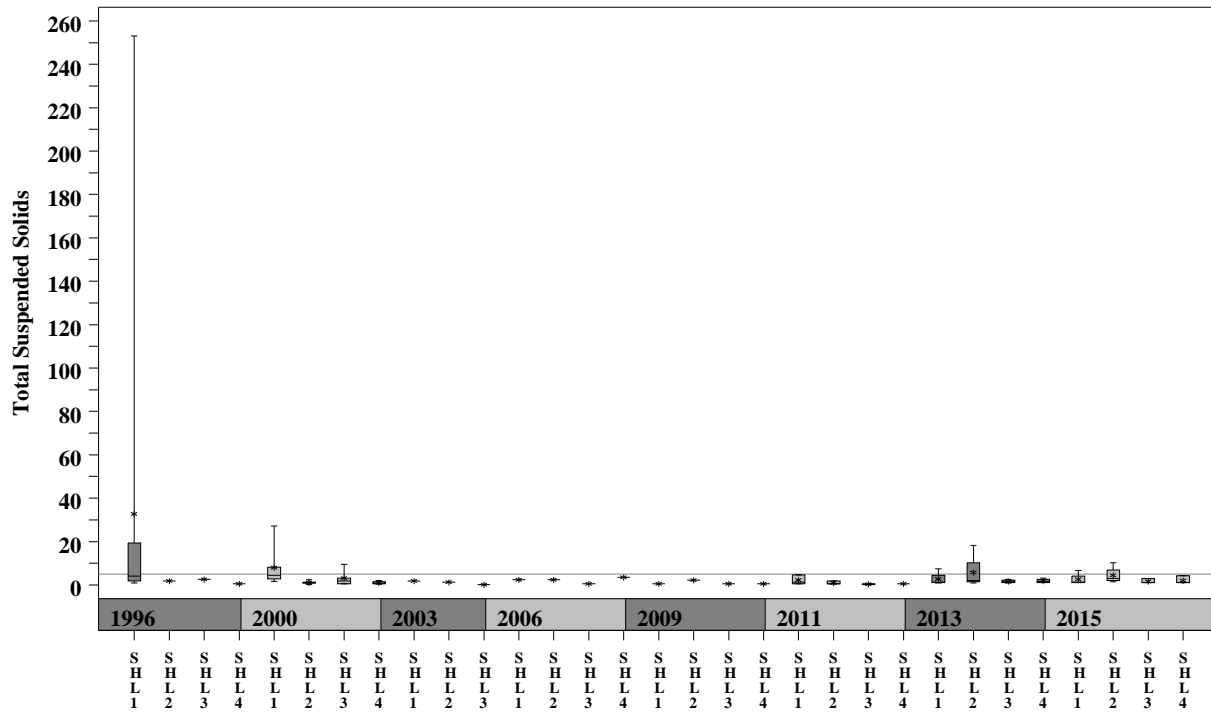
Gray highlighting indicates that the value exceeds one standard deviation from the mean of all E.I.I. sites combined.

Summary Statistics for all 2015-2016 E.I.I. Sites Combined				
Parameter	2015-2016 Average	2015-2016 Minimum	2015-2016 Maximum	1 Standard Deviation Above
NH3-N (mg/l)	0.018	0.008	0.881	0.085
NO3-N (mg/l)	1.14	0.01	12.0	3.16
Ortho-P (mg/l)	0.016	0.004	0.661	0.08
T.S.S. (mg/l)	3.7	1.0	58.2	9.7
Turbidity (NTU)	4.4	0.2	98.6	11.7

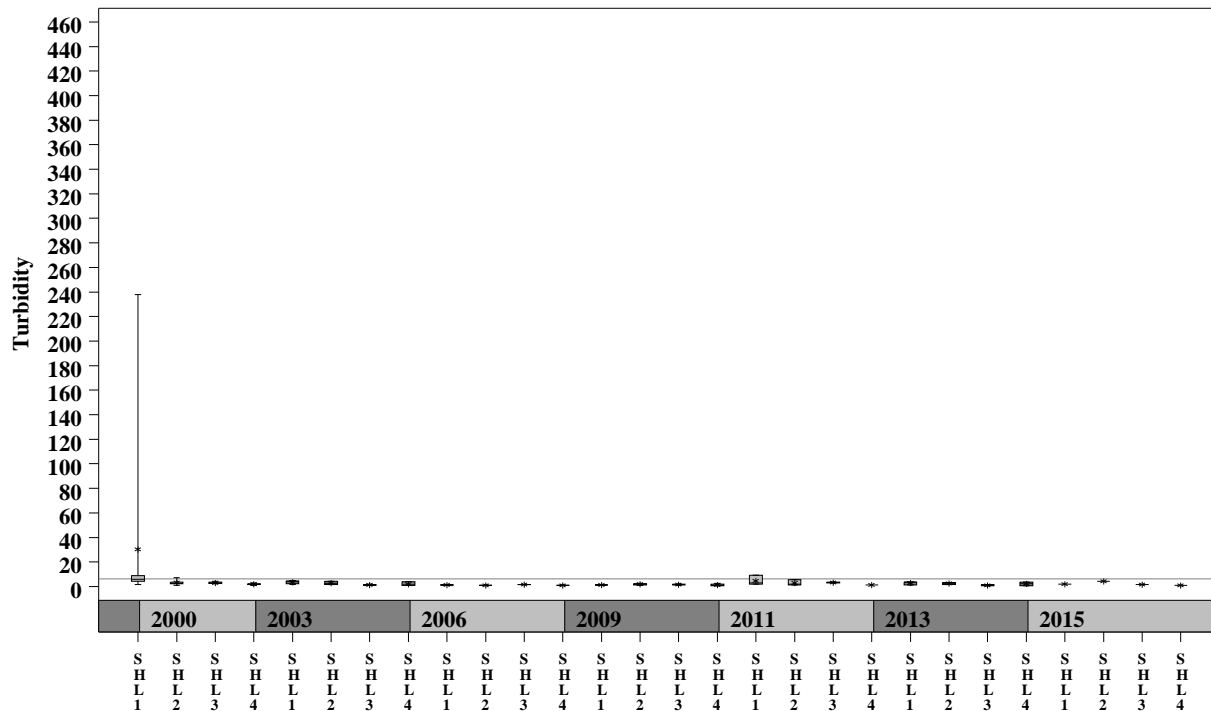
Shoal Creek Watershed

Data Summary Graphs – Total Suspended Solids and Turbidity (Downstream to Upstream by Year)

Parameter=TOTAL SUSPENDED SOLIDS Unit=mg/L Watershed=Shoal



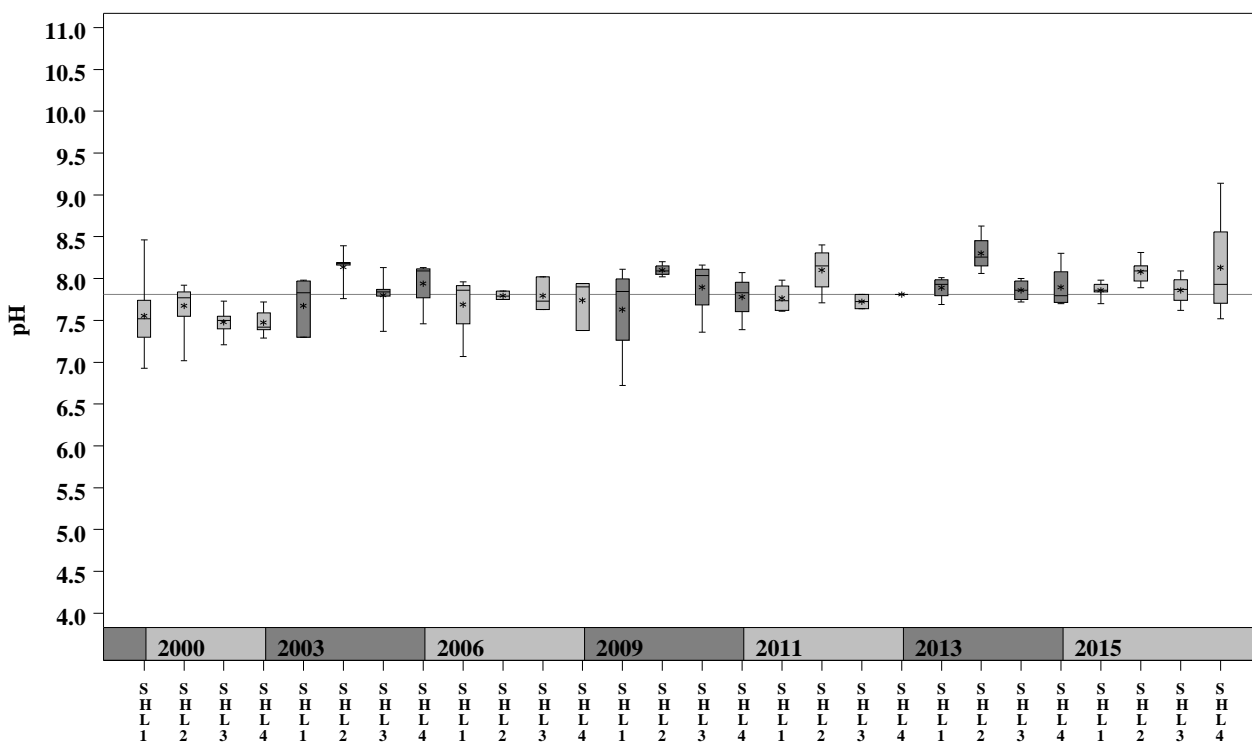
Parameter= TURBIDITY Unit=NTU Watershed=Shoal



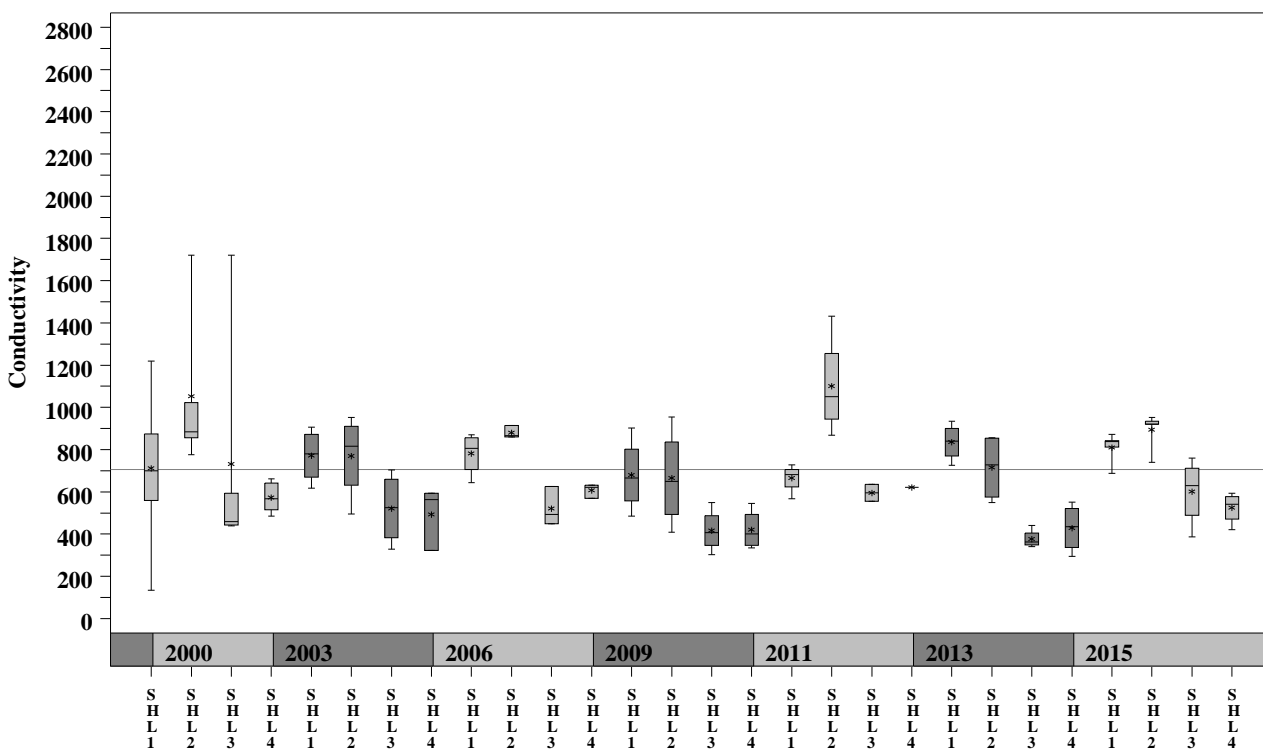
Shoal Creek Watershed

Data Summary Graphs – pH and Conductivity (Downstream to Upstream by Year)

Parameter = pH Unit = Standard Units Watershed = Shoal



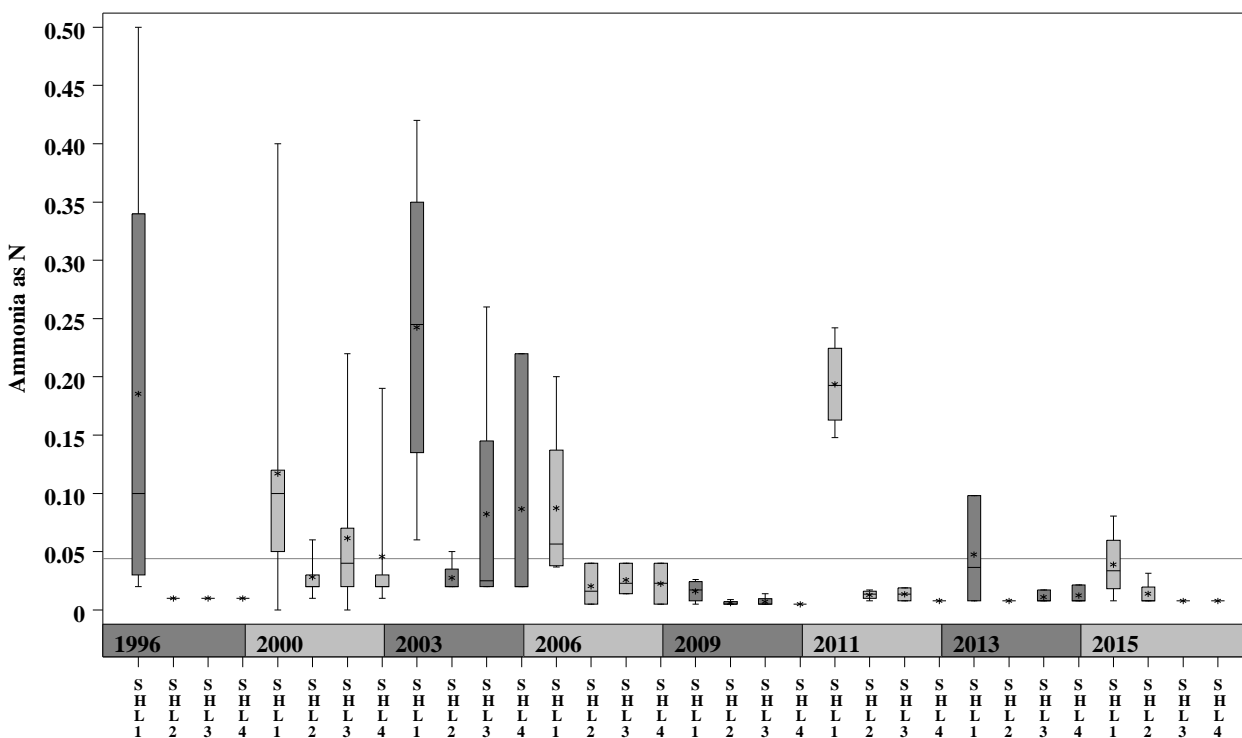
Parameter = CONDUCTIVITY Unit = uS/cm Watershed = Shoal



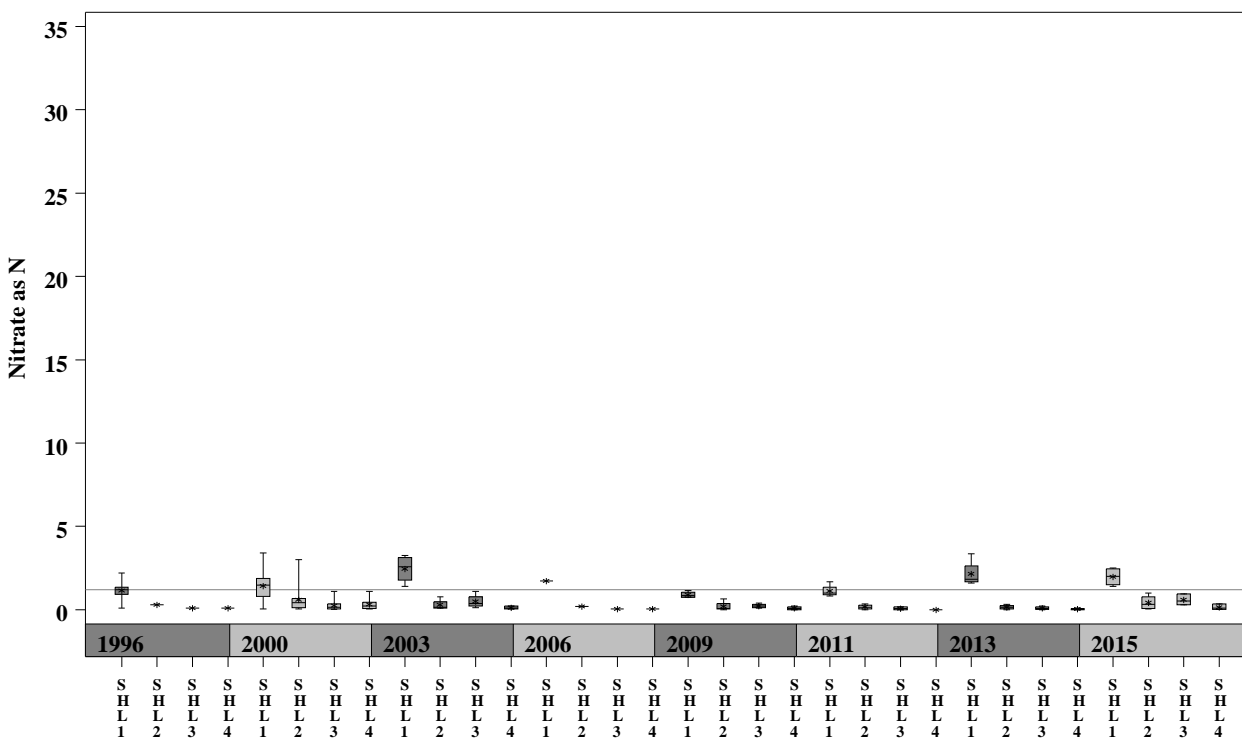
Shoal Creek Watershed

Data Summary Graphs – Ammonia and Nitrate/Nitrite (Downstream to Upstream by Year)

Parameter = AMMONIA AS N Unit = mg/L Watershed = Shoal



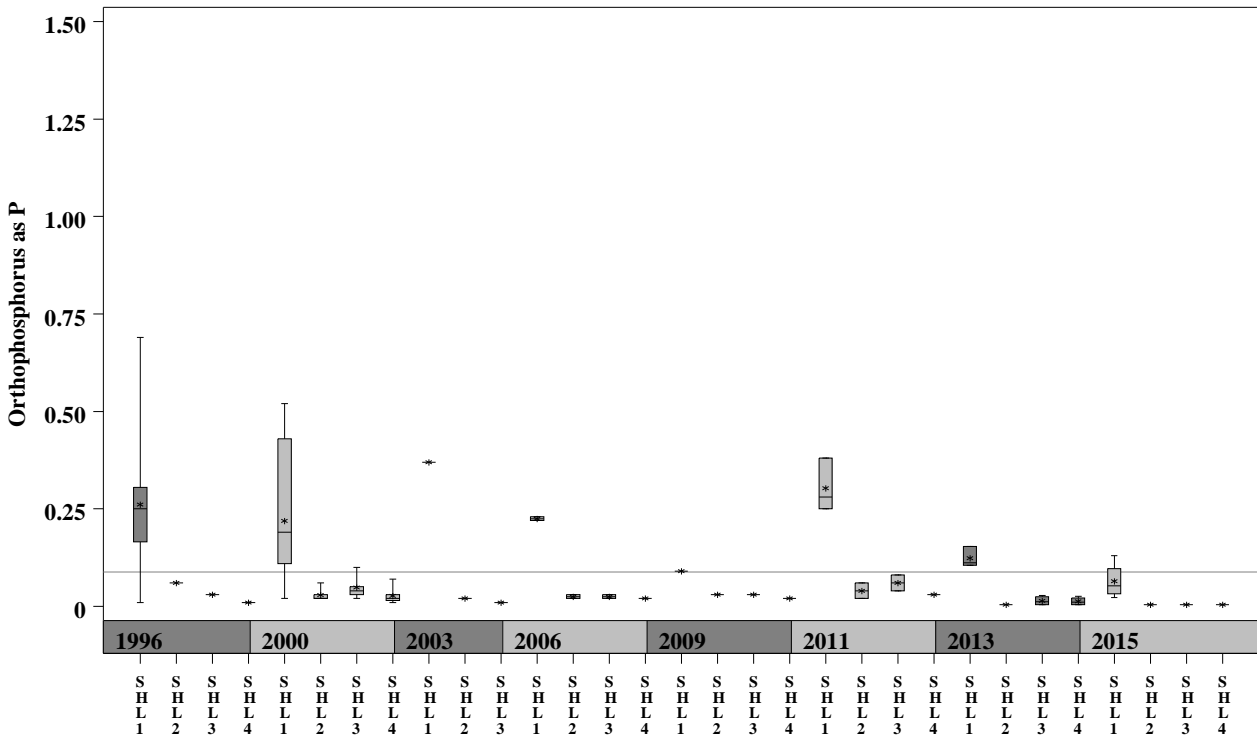
Parameter = NITRATE AS N Unit = mg/L Watershed = Shoal



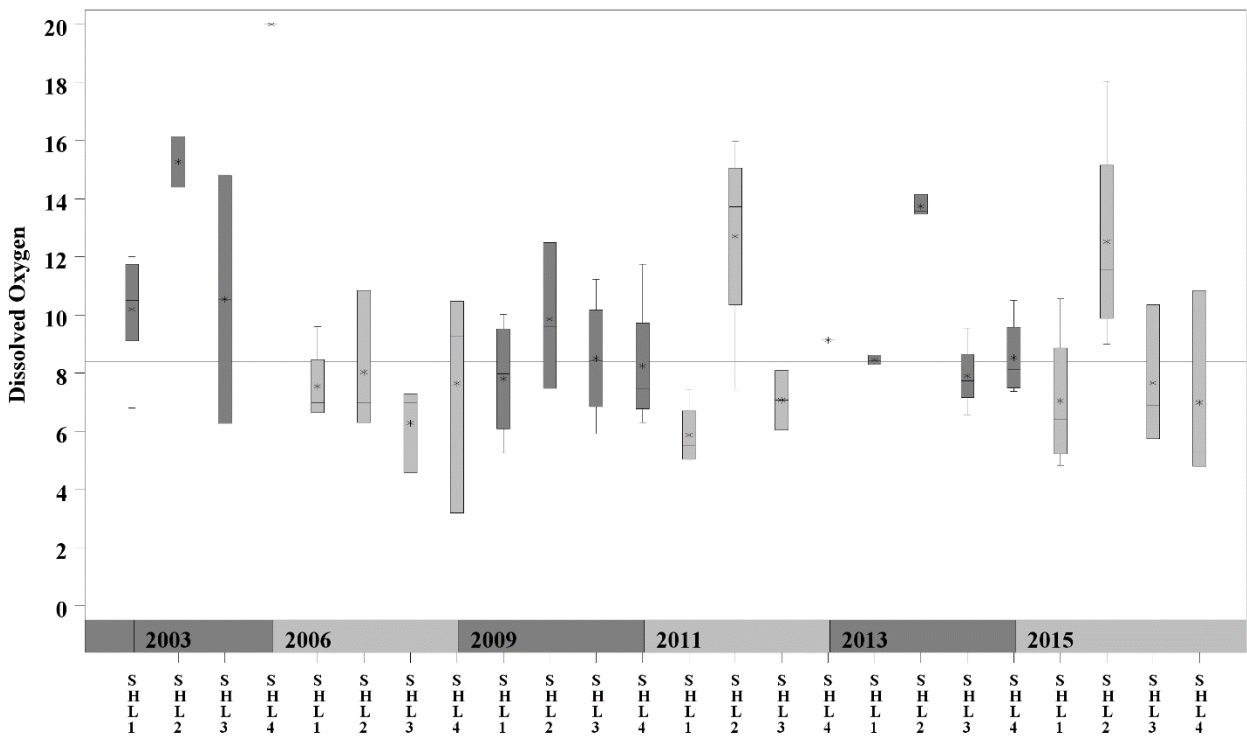
Shoal Creek Watershed

Data Summary Graphs – Orthophosphate and Dissolved Oxygen (Downstream to Upstream by Year)

Parameter = ORTHOPHOSPHORUS AS P Unit = mg/L Watershed = Shoal



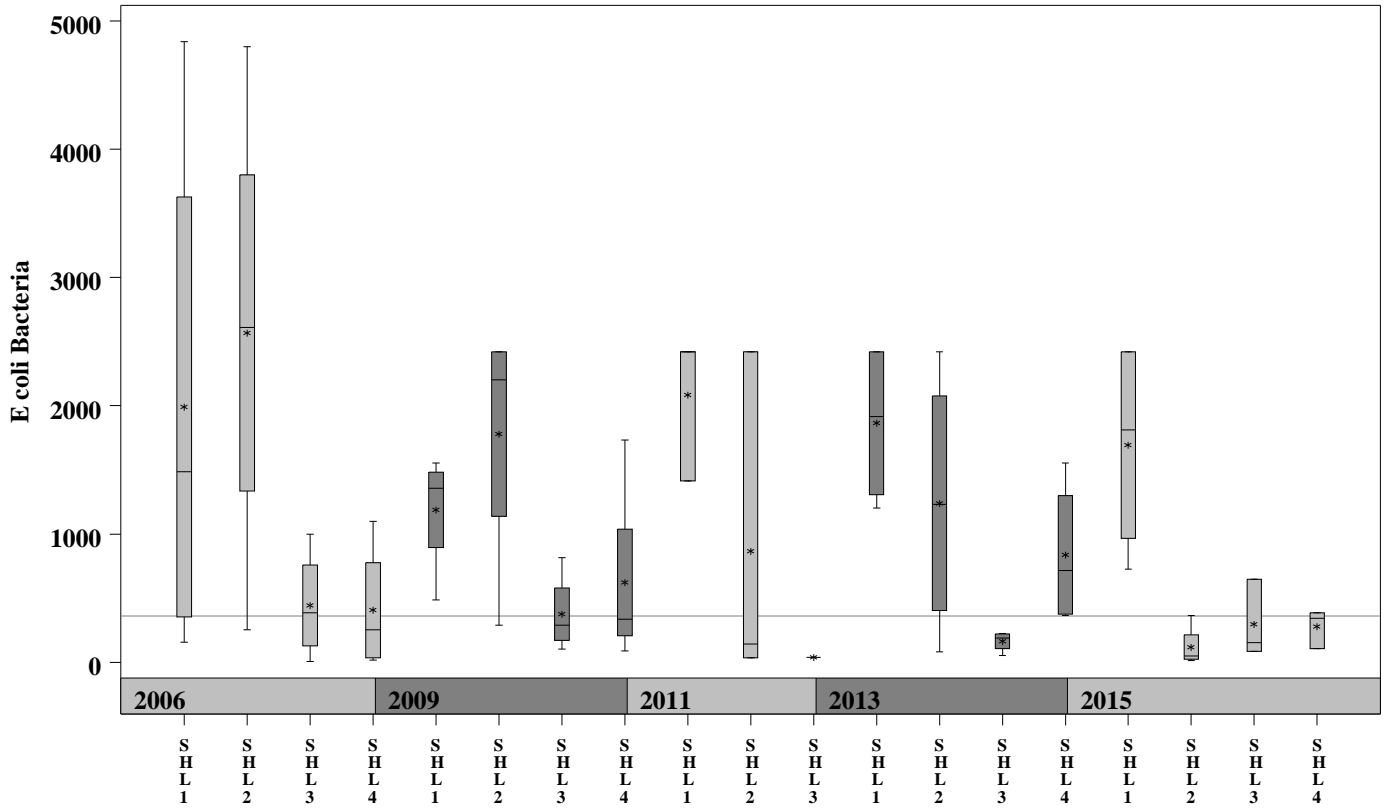
Parameter = DISSOLVED OXYGEN Unit = mg/L Watershed = Shoal



Shoal Creek Watershed

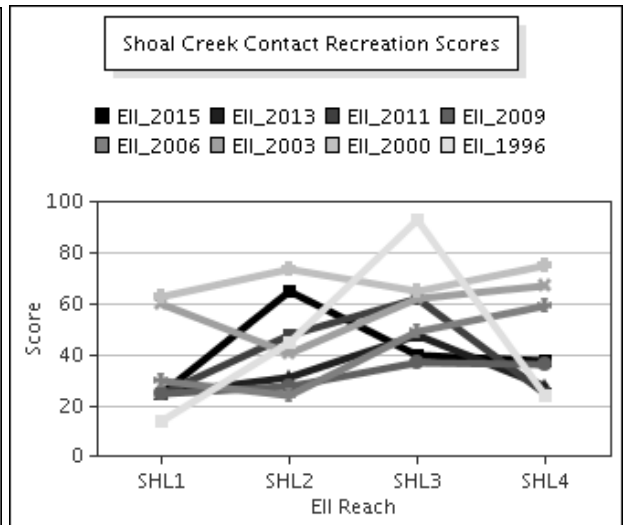
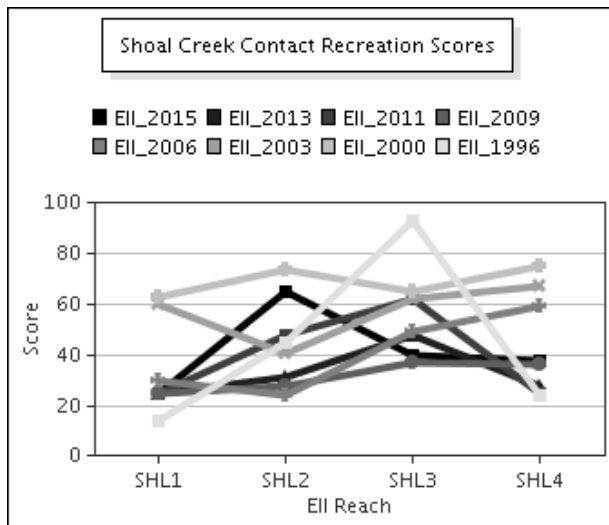
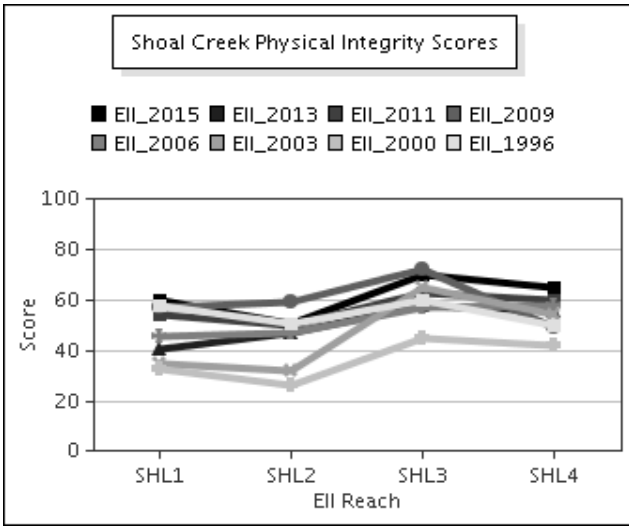
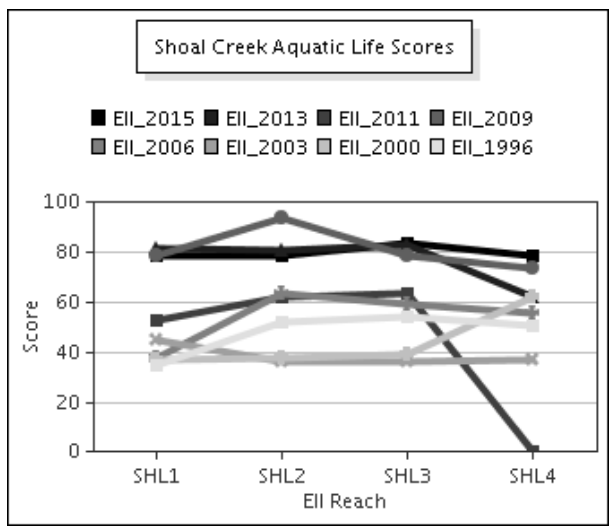
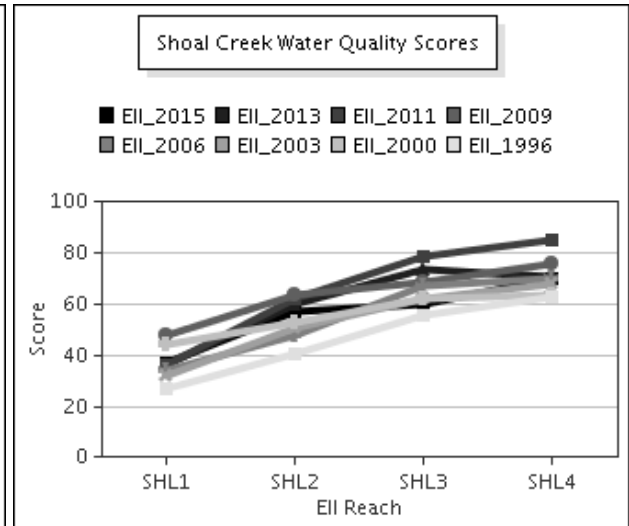
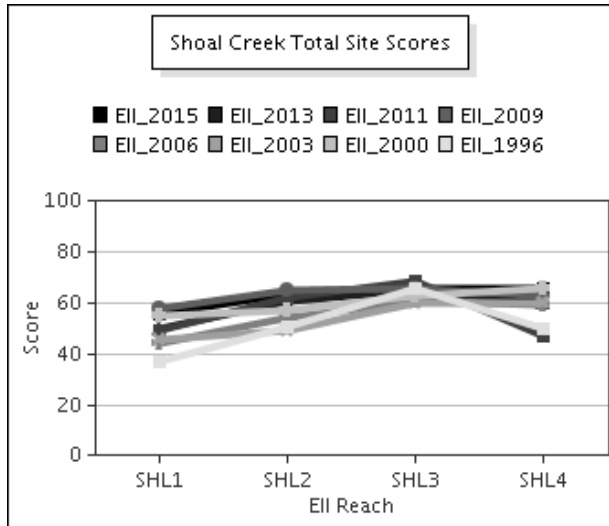
Data Summary Graphs – *E.coli* (Downstream to Upstream by Year)

Parameter = E COLI BACTERIA Unit = MPN/100mL Watershed = Shoal



Shoal Creek Watershed

Score Summary – Reach scores for each sample year



Shoal Creek Watershed

Benthic Macroinvertebrates – Taxa List, Pollution Tolerance Index & Functional Feeding Group for 2015 Sample Sites (Downstream to Upstream)

Benthic Macroinvertebrates - Shoal Creek			SHL @ Crosscreek (118) 07/08/2015 (WRE)	SHL @ Shl Edge Ct (117) 07/08/2015 (WRE)	SHL @ 24th (116) 07/10/2015 (WRE)	SHL us 1st (122) 07/10/2015 (WRE)
Benthic Macroinvertebrate ID	PTI	FFG				
Chimarra	2	FC	7	76	23	2
Hydroptila	2	PI,SC				1
Camelobaetidius	4	CG	3	30	18	3
Fallceon	4	CG,SC	44	83	158	119
Neochoroterpes	4	CG	7		2	
Ostracoda	4	CG,FC				1
Simulium	4	FC	1	11		3
Petrophila (Moth)	5	SC	1	2		
Argia	6	P	26	38		7
Brechmorhoga Mendax	6	P	7		1	
Cheumatopsyche	6	FC	4	71	26	2
Chironomidae	6	FC,P	17	32	10	3
Hetaerina	6	P		2		
Rhagovelia	6	P	3			
Tanypodinae	6	P	9		9	1
Caenis	7	CG,SC		1	12	
Stenelmis	7	CG,SC	2	1		
Hirudinea	8	P		2		
Hyalella	8	CG,SH	2	10	1	2
Oligochaeta	8	CG		1		1
Physella	9	SC			2	
Belostoma	10	P	1			
Dugesia		CG,P	64	1	5	

